IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of

Karsten EMRICH et al.

Corres. to PCT/EP2003/005516

For: HEAT EXCHANGER, PARTICULARLY A CHARGE-AIR COOLER FOR MOTOR VEHICLES

TRANSLATOR'S DECLARATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, the below-named translator, certify that I am familiar with both the German and the English language, that I have prepared the attached English translation of International Application No. PCT/EP2003/005516, and that the English translation is a true, faithful and exact translation of the corresponding German language paper.

I further declare that all statements made in this declaration of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of legal decisions of any nature based on them.

December 15, 2004

Date

Name: Nigel David CROSSAN
For and on behalf of RWS Group Ltd

10/519709
DT01 Rec'd PCT/PTO 30 DEC 2004

Gleiss & Große
European Patent Attorneys
European Trademark Attorneys

Intellectual Property Law
Technology Law

Leitzstraße 45
D-70469 Stuttgart

Patent Application

Heat exchanger, in particular charge-air cooler for motor vehicles

BEHR GmbH & Co. KG
Mauserstraße 3
D-70469 STUTTGART

10/519709
DT01 Rec'd PCT/PTO 30 DEC 2004

5/PRTS

Heat exchanger, particularly charge-air cooler for motor vehicles

Description

The invention relates to a heat exchanger, particularly charge-air cooler for motor vehicles, preferably for utility vehicles, having a first collecting vessel and a second collecting vessel for a first medium, wherein the two collecting vessels each have a first media connection for the first medium and are connected to one another in a communicating manner via at least one heat exchanger element, and having a housing which accommodates the heat exchanger element, conducts a second medium in the interior and has second media connections for the second medium.

Such heat exchangers are known. They are used in motor vehicles to make available cooled charge air. The charge air is cooled by means of cooling air, with the slip stream of the vehicle or ambient air which is fed by a fan being used as the cooling air. The two collecting vessels of the known heat exchanger are connected to one another, for example, by means of charge air pipes, with cooling ribs being arranged between the charge air pipes in order to increase the surface. The cooling air flows through these cooling ribs and a housing which accommodates the charge air pipes is provided. The housing is formed by housing walls which span the intermediate space between the two collecting vessels. The cooling air enters the housing transversely with respect to the longitudinal extent of the charge air pipes, at a lateral distance from one of the collecting vessels, is deflected there through 90°, flows through the housing in the direction of the charge air pipes and leaves the housing at a distance from the other collecting vessel in a direction which

is at right angles to the longitudinal extent of the charge air pipes. The aforementioned deflection of the cooling air brings about a relatively large loss in pressure. In addition, the cooling air is not in contact with the entire length of the charge air pipes, that is to say the sections of the charge air pipes which adjoin the respective collecting vessel are not cooled, or are not cooled sufficiently, by the cooling air. For this reason, the overall level of efficiency is not adequate.

The invention is based on the object of specifying a heat exchanger of the type mentioned at the beginning which provides a very good heat exchanging function, in particular cooling capacity, without increasing the overall size and with only a small requirement for cooling air.

This object is achieved according to the invention by virtue of the fact that the housing is embodied in such a way that at least one collecting vessel, preferably both collecting vessels, is/are accommodated in the interior of said housing, at least in part with a distance from the inner wall of the housing, at least in certain areas. This design according to the invention makes it possible to locate the two media connections in such a way that the entire or almost the entire length of the heat exchanger element, in particular the charge air pipes, has the second medium applied to it and therefore a correspondingly high level of efficiency is achieved. The second media connections can be arranged, for example, in the region of the collecting vessels in such a way that the second medium firstly flows on the outside along part of the assigned collecting vessel or along the entire collecting vessel, then arrives at the heat exchanger element and performs the heat exchanging process over a correspondingly large distance. If the medium then enters the region of the other collecting vessel, it

flows there at least along part of the distance on the outside and leaves the arrangement via the second media connection. The distance which is present at least in certain areas between the inner wall of the housing and at least one collecting vessel, preferably both collecting vessels, ensures that the second medium can flow via the second media connection and into the housing and to the heat exchanger element. The same applies to the medium flowing out of the housing, that is to say that in such a case the second medium can flow through the heat exchanger element to its end and only then is it conducted away.

According to one development of the invention there is provision for the housing to accommodate the collecting vessels completely. This arrangement provides, on the one hand, the aforementioned largest possible contact distance between the second medium and the heat exchanger element, and also provides the possibility of arranging the second media connections for the second medium to be supplied and conducted away, in such a way that the smallest possible pressure loss occurs, that is to say the second medium is as far as possible not directed or is repeatedly greatly deflected in its direction in such a way that a perceptible loss in pressure occurs. In particular it is possible to provide for the two media connections to be assigned to the two collecting vessels in such a way that the first collecting vessel is located between the second media connection and the heat exchanger element, and the second collecting vessel is located between the other second media connection and the heat exchanger element. In such a case, the inflowing second medium firstly arrives at the collecting vessel, flows along it or flows around it and then arrives at the heat exchanger element, from there passes to the other collecting vessel, flows along it or around it and then passes to the second media connection which conducts away the second medium. The directions of flow are selected such

that the second medium has the same or approximately the same direction in the region of the second media connections as in the heat exchanger element, that is to say said directions do not extend transversely with respect to the flow in the heat exchanger element and conducted away, as in the prior art, but rather extend in the same direction. Correspondingly, only a small loss of pressure occurs, in particular if the flow-around profile of the respective collecting vessel is configured such that the medium flows along or around the respective collecting vessel in a laminar fashion, that is to say the second medium flows essentially without eddying.

According to one development of the invention there is provision for the direction of flow of the first medium in the collecting box to extend transversely, in particular at right angles, with respect to the direction of flow of the first medium in the heat exchanger element. The first medium therefore flows into the collecting vessel and leaves it transversely with respect to the direction of flow in the collecting vessel, that is to say is deflected in the collecting vessel, in particular is deflected at right angles, flows through the heat exchanger element and arrives at the second collecting vessel. In said second collecting vessel, the medium is in turn deflected in the direction of the longitudinal extent of the collecting vessel, in particular it is deflected at right angles. The first medium then leaves the second collecting vessel. The deflection or deflections of the first medium are less significant since the medium here is preferably the charge air of a charge-air cooler which forms the heat exchanger and said charge air is present under high pressure so that losses of pressure due to deflection can be accepted. According to the invention this does not apply to the second medium, for example for charge air of the charge-air cooler, since this charge air is at a lower pressure, for example if it is

slip stream or ambient air which is fed by a fan.

It is advantageous if the second media connections point in the direction, or approximately in the direction, of flow of the first medium in the heat exchanger element. Details have already been given on this above, that is to say the second medium flushes through the entire collecting vessels at it flows into or flows out of the heat exchanger element.

It is possible to provide for the two media connections to point in the transverse direction, in particular at right angles with respect to the direction of flow of the first medium in the heat exchanger element. Details on this have already been given: the first medium is deflected in the first collecting vessel after it passes through the first media connection, and it then passes through the heat exchanger element again and arrives at the second collecting vessel and, by deflection once more, at the further first media connection which directs away the first medium.

In particular it is possible to provide for the housing to be in the shape of a bone when viewed in cross direction or its shape is approximated to a bone shape. The first and the second collecting vessels are arranged in the region of the two thickened portions of the bone shape, that is to say each thickened portion has an assigned collecting vessel, the housing being at a distance from the respective collecting vessel so that the second medium can flow along on the outside of the respective collecting vessel in the interior of the housing. Between the two thickened portions of the housing which form the bone shape there is a less thick region in which the heat exchange element is located.

According to one development of the invention there is provision for the walls of the housing to bear snugly against the heat exchanger element. These are side

walls of the housing and also bottom and top walls. This snugly bearing arrangement causes the second medium to enter into intensive heat exchanging contact with the second medium without an incorrect flow of medium which flows along the inner wall of the housing but in doing so does not have sufficient heat exchanging contact with the first medium.

According to one development of the invention there is provision for the housing to form a housing section of a fan housing of a fan. Consequently, the heat exchanger according to the invention is integrated into the housing of the fan, that is to say the entire fan housing has the impeller of the fan and also the heat exchanger, which brings about a very space-saving shape. The fan housing can preferably be embodied as a helical housing.

It is particularly preferred if the heat exchanger is embodied as a counter flow heat exchanger, that is to say the first and the second medium flow in opposite directions from one another in the region of the heat exchanger element so that a high degree of heat exchange is obtained with a low cooling air volume flow. However, it is alternatively also possible for the heat exchanger to be embodied as a co-current heat exchanger, that is to say the first and second media flow in the same direction in the heat exchanger element. Finally, there may also be a mixed design of the two aforesaid possibilities, that is to say there is a counter flow in certain subsections and a co-current flow in other subsections. In addition, or alternatively, it is also conceivable for a cross-current heat exchanger to be formed.

The drawings illustrate the invention by means of exemplary embodiments, specifically:

Figure 1 shows a longitudinal section through a heat

exchanger whose shape is approximated to a bone shape,

Figure 2 shows a plan view of the plate contour of a heat exchanger element of a heat exchanger, partially in section,

Figure 3 shows a further embodiment of a heat exchanger, partially broken open,

Figure 4 shows an enlarged detailed view of the heat exchanger in Figure 3,

Figure 5 shows a section along the line V-V in Figure 2,

Figure 6 shows a section along the line VI-VI in Figure 2, and

Figure 7 shows a further exemplary embodiment of a heat exchanger integrated into the fan housing of a fan.

Figure 1 shows a heat exchanger 1 which serves as a charge-air cooler of a utility vehicle. The heat exchanger 1 has a first collecting vessel 2 and a second collecting vessel 3, located at a distance from the latter, for a first medium 4. The first medium 4 is charge air 5. The charge air 5 is intended to be cooled by means of a second medium 6. The second medium 6 is cooling air 7, the air which is formed by the slip stream and/or sucked in by a blower (not illustrated). The two collecting vessels 2 and 3 are tubular, formed of an oval cross section; their longitudinal extent extends perpendicularly with respect to the plane of the drawing in Figure 1.

The heat exchanger 1 has a housing 8 which is in a bone shape when viewed in the longitudinal section in Figure

1. Between two thickened regions 9 and 10 of the housing 8 there is a less thick region 11 in which the housing 8 has two planar walls 12, 13. In the thickened regions 9 and 10, the respective planar wall 12 and 13 merges with convexly bent walls 14, 15 and 16, 17. The housing 8 ends in regions 18, 19 which are thinner, viewed in the longitudinal section in Figure 1, than the region 11 and each have an end side 20 or 21. The convexly curved walls 14, 15, 16 and 17 extend at a distance a from the respective collecting vessel 2 or 3 so that flow paths 22 to 25 are formed in the region of the collecting vessels 1 and 2 in such a way that medium can flow around on the outside of the latter inside the housing 8. The thickened regions 9 and 10, which cause the bone shape to be formed, make this possible.

The charge air 5 is fed to the second collecting vessel 3, perpendicularly to the plane of the drawing in Figure 1, by means of a first media connection 26 (not illustrated in more detail). The charge air 5 thus rises in the second collecting vessel 3 and is then deflected by 90° in the direction of the first collecting vessel 2. It passes through a heat exchanger element 27 which is located between the two collecting vessels 3, 2. This is integrated by means of the dashed arrow 28. After the medium passes through the heat exchanger element 27, the charge air 5 enters the first collecting vessel 2, is deflected downward there by 90° and leaves the collecting vessel 2 by means of a first media connection 29 (not illustrated in more detail). The heat exchanger element 27 can be formed by the charge air pipes which extend parallel to one another and connect the two collecting vessels 2, 3 in a communicating manner (not illustrated in more detail). The charge air pipes extend at right angles to the longitudinal extents of the collecting vessels 2 and 3. In order to increase the surface it is possible to arrange cooling air ribs between the individual charge

air pipes which are spaced apart from one another, the cooling air 7 flowing through the cooling air ribs in the opposite direction from the direction of the charge air 5 so that an intensive exchange of heat takes place in the heat exchanger element 27 and causes the charge air 5 to be cooled by the cooling air 7. For this purpose, the cooling air 7 is let into the interior of the housing 8, by means of a second media connection 30 located on the end side 20 of the region 18, in such a way that said cooling air passes through the two flow paths 22 and 23 and thus at least partially flushes through the second collecting vessel 3. The cooling air 7 then enters the heat exchanger element 27 and flows through this component according to the counter flow principle, that is to say the direction of flow of the charge air 5 is opposed to the direction of flow of the cooling air 7. The cooling air 7 leaves the heat exchanger element 27 in the region of the second collecting vessel 3 and flows into the flow paths 24 and 25, that is to say the cooling air flows around the collecting vessel 3 on both sides. The cooling air 7 then passes to the end side 21 of the region 19 where a second media connection 31 is formed to conduct away the cooling air 7.

From Figure 1 it is very clear that the cooling air 7 does not experience any significant deflection in the region of the heat exchanger 1, not even in the region of the heat exchanger element 27. Although the cooling air 7 flows around the two collecting vessels 2 and 3 with a certain change in direction of the cooling air 7, this change in direction does not entail any appreciable loss in pressure since a laminar flow can be formed. The two second media connections 30 and 31 thus point in the direction of the flow of charge air 5 from cooling air 7 within the heat exchanger element 27.

Figure 2 shows a plan view of a plate contour of the heat exchanger element 27, that is to say the heat exchanger element 27 is embodied in a stacked plate design. For this purpose, individual plates (profiled pieces of sheet aluminium) are alternately laid one on top of the other and are provided with bowls and rim holes in order to form the connection and to form the two collecting vessels 2 and 3. This is basically known. When the plates are stacked one on top of the other, bowl/rim hole is laid to bowl/rim hole and then the next pair is positioned edge to edge etc. and soldered. As a result of this stacking, a cooling air rib 32, a charger rib 33 and then again a cooling air rib 32 and, subsequently, a charge air rib 33 etc. are formed in the heat exchanger element 27 according to Figure 5. From Figure 5 it is clear that the flow path for the charge air 5 is created in the region of the heat exchanger element 27 by laying two half shells 34, 35 one on top of the other. The adjacent charge air rib 33 is at a distance from the first-mentioned charge air rib 33 so that a cooling air rib 32, through which cooling air 7 can flow in a counter flow fashion, is formed between them. In order to be able to feed the charge air 5 and the cooling air 7 to their respective flow paths inside the heat exchanger element 27 in the region of the collecting vessels 2 and 3, there is provision, according to the plate design in Figure 6, for the charge air ribs 33 to be connected to one another there, in order to form the collecting vessel 2 or 3, so that the charge air 5 passes through the cooling ribs 32 in a separated-off fashion and flows into the regions of the charge air ribs 33 and then passes through the heat exchanger element 27 in a correspondingly divided fashion, as it were in the plane of the drawing in Figure 6. The same takes place in the region of the other collecting vessel; the charge air is combined there again and conducted away in one stream. The cooling air ribs 32 are connected to

the flow paths 22 to 25, that is to say the cooling air 5 passes through them.

The overall design of a heat exchanger 1 described above in a stacked plate design is shown in more detail in Figures 3 and 4. Figure 3 shows the housing 8 which surrounds the heat exchanger element 27, the housing 8 having the two media connections 30 and 31 at ends lying diametrically opposite one another. In addition, the first media connections 26 and 29 which lead to the collecting vessels 2, 3 are shown.

From Figure 4 it is apparent that charge air 5 coming from the heat exchanger element 27 is directed via the charge air ribs 33 and conducted away from the collecting vessel 2 according to the arrows 35. In contrast, the cooling air ribs 32 lying between the charge air ribs 33 conduct cooling air 7 according to the arrow 36, according to the counter flow principle.

In the exemplary embodiment in Figures 2 to 4 it is also ensured that the cooling air 7 does not need to be deflected, or only deflected insignificantly, in order to enter the heat exchanger element 27 so that only small losses in pressure occur.

Figure 7 shows a fan 37 with fan housing 38 and impeller 39. A heat exchanger element 27 is at least partially integrally incorporated according to the exemplary embodiments described above in such a way that cooling air 7 which is conducted within the fan housing 38 can flow through the heat exchanger element 27 according to the arrows shown in Figure 7. Owing to the stacked design, the heat exchanger element 27 has integrated collecting vessels 2 and 3 and cooling air ribs 32 and charge air ribs 33 between them so that a charge air stream which is conducted there is cooled by the cooling air 7. The housing 38 is preferably embodied as a helical housing 40.